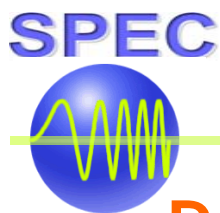


# *ETO Light* Power Converter for FACTS & Energy Storage Applications

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Funded in part by the Energy Storage Systems Program of the U.S. Department Of Energy (DOE/ESS) through Sandia National Laboratories (SNL)



# FY2006 Project Objectives

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**Develop a modular VSC for multiple FACTS and energy storage applications with goals of achieving**

## **1. Lower cost**

- **Using lower cost power devices**
- **Reducing component parts**
- **Modular approach**

## **2. Higher reliability**

- **Reducing components parts**

## **3. High power density**

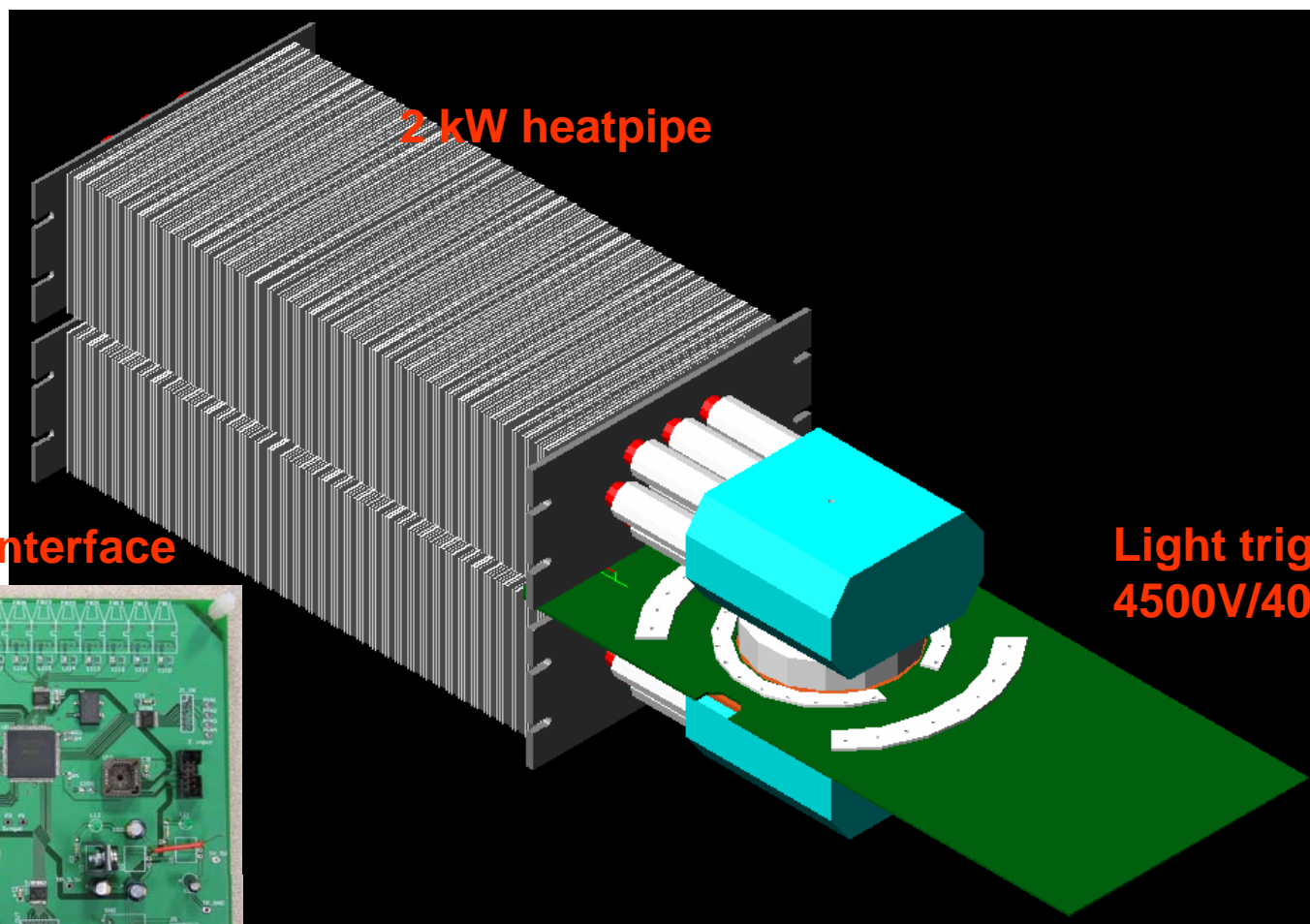
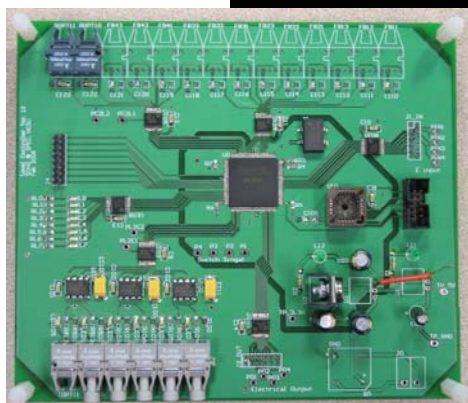
- **Better utilization of silicon**
- **Reducing component parts**

Based on three key technologies

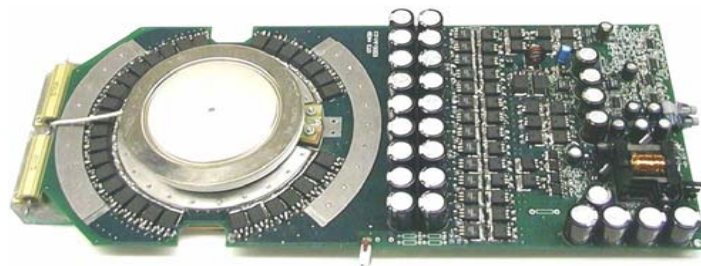
2 kW heatpipe

Digital interface

Light triggered ETO  
4500V/4000A



# Light Triggered Emitter Turn-off Thyristor



## Lower cost

- lower cost device based on mature GTO technology
- eliminating snubbers and auxiliary power supplies

## Higher reliability

- eliminating auxiliary power supplies and snubber networks
- light trigger interface improve noise immunity

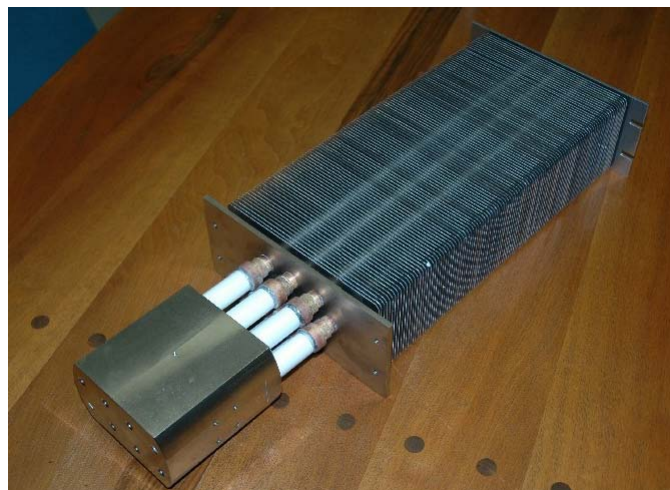
## High power density

- large turn-off capability (4000A) allows thermally limited VSC design

- reduced parts allow compacter design

More information of the ETO has been presented in previous ESS reviews

## Heatpipe Cooling System



### **Lower cost**

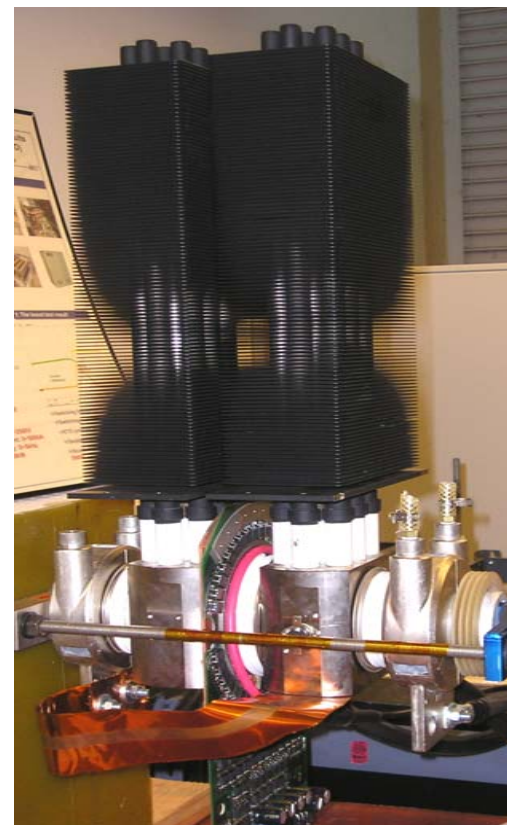
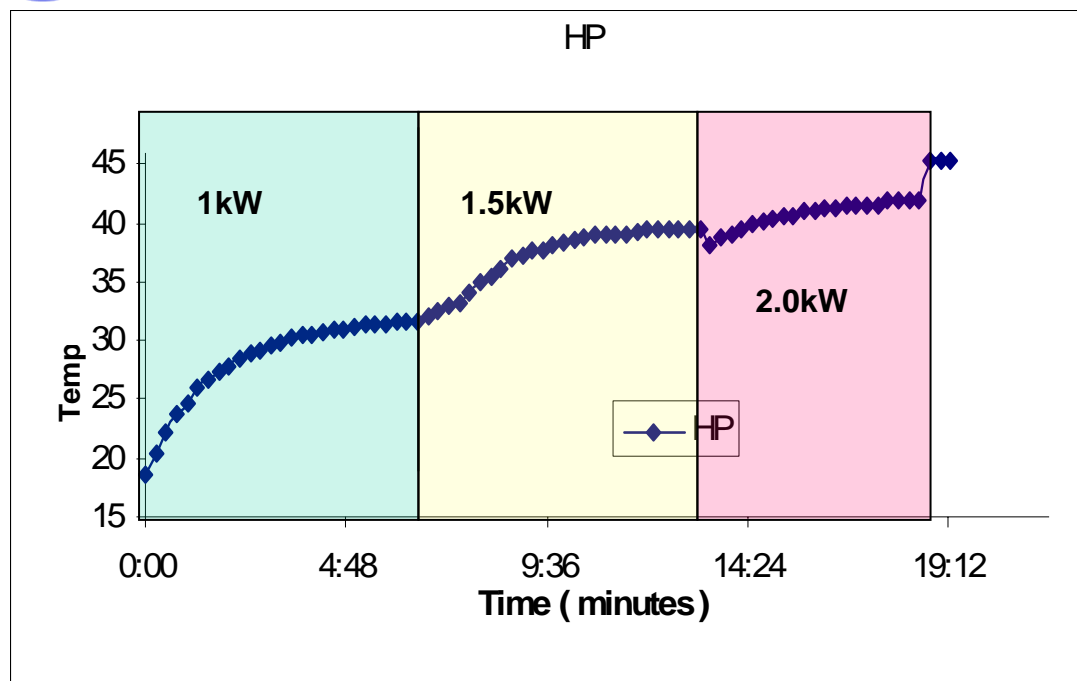
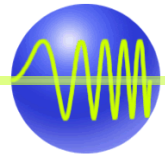
**lower cost by eliminating heat exchanger and pipes in water cool system**

### **Higher reliability**

**eliminating pumps, pipes and water**

### **High power density**

**reduced parts allow compacter design**



- Thermal resistance (junction-ambient) for the ETO with double side heatpipes is determined as **35K/kW**
- Capable of removing around **2.5 kW** of heat from ETO even at  $T_a=40^{\circ}\text{C}$

## Modular Construction and Digital Interface

### Rating:

- 1.0 MVA to 2 MVA/per module
- Size ~ 0.6 cubic meter

### Power Stage:

- Two VDC Ports;
- Two AC Ports;

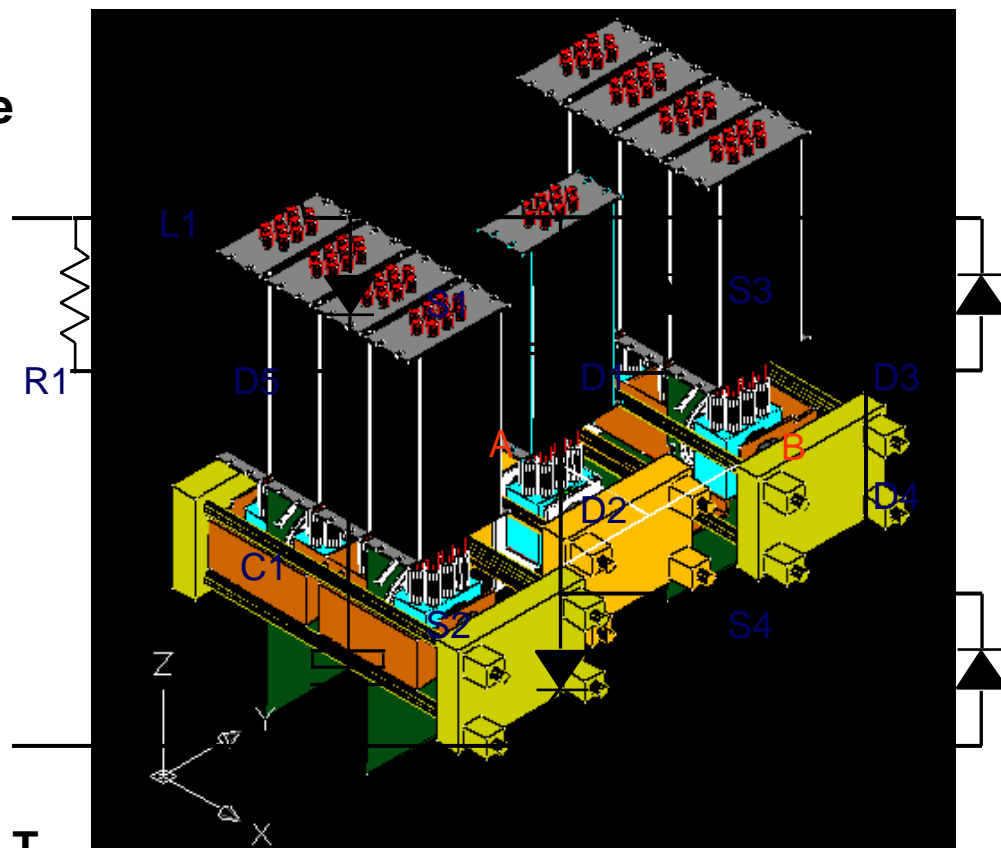
### Digital Control Interface:

- One optical fiber in;
- One optical fiber out;

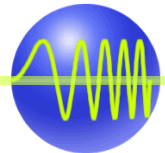


### Intelligence:

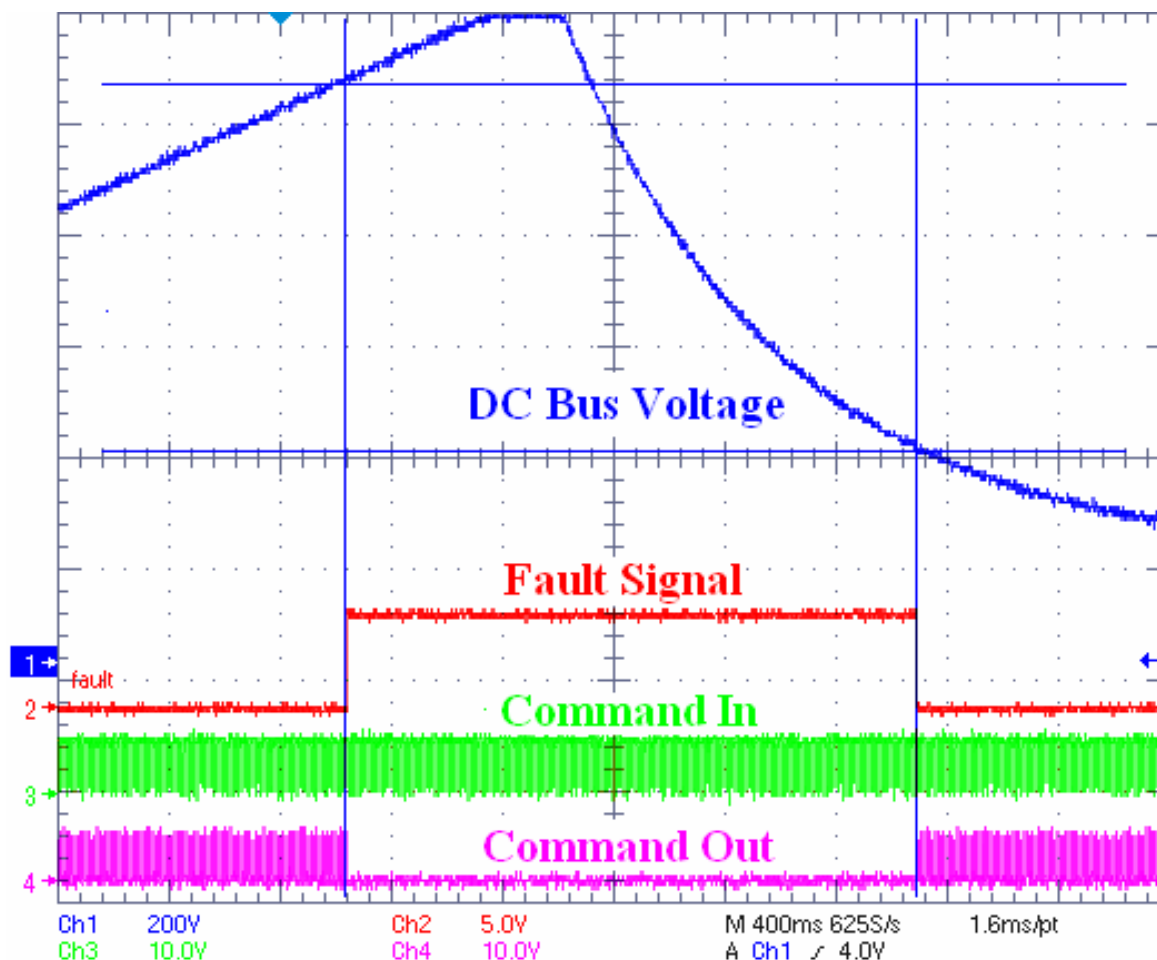
- Sensorless V, I, T sense & protections
- Programmable fail open or fail short





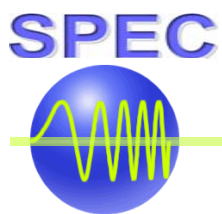


# Over Voltage Protection of VSC

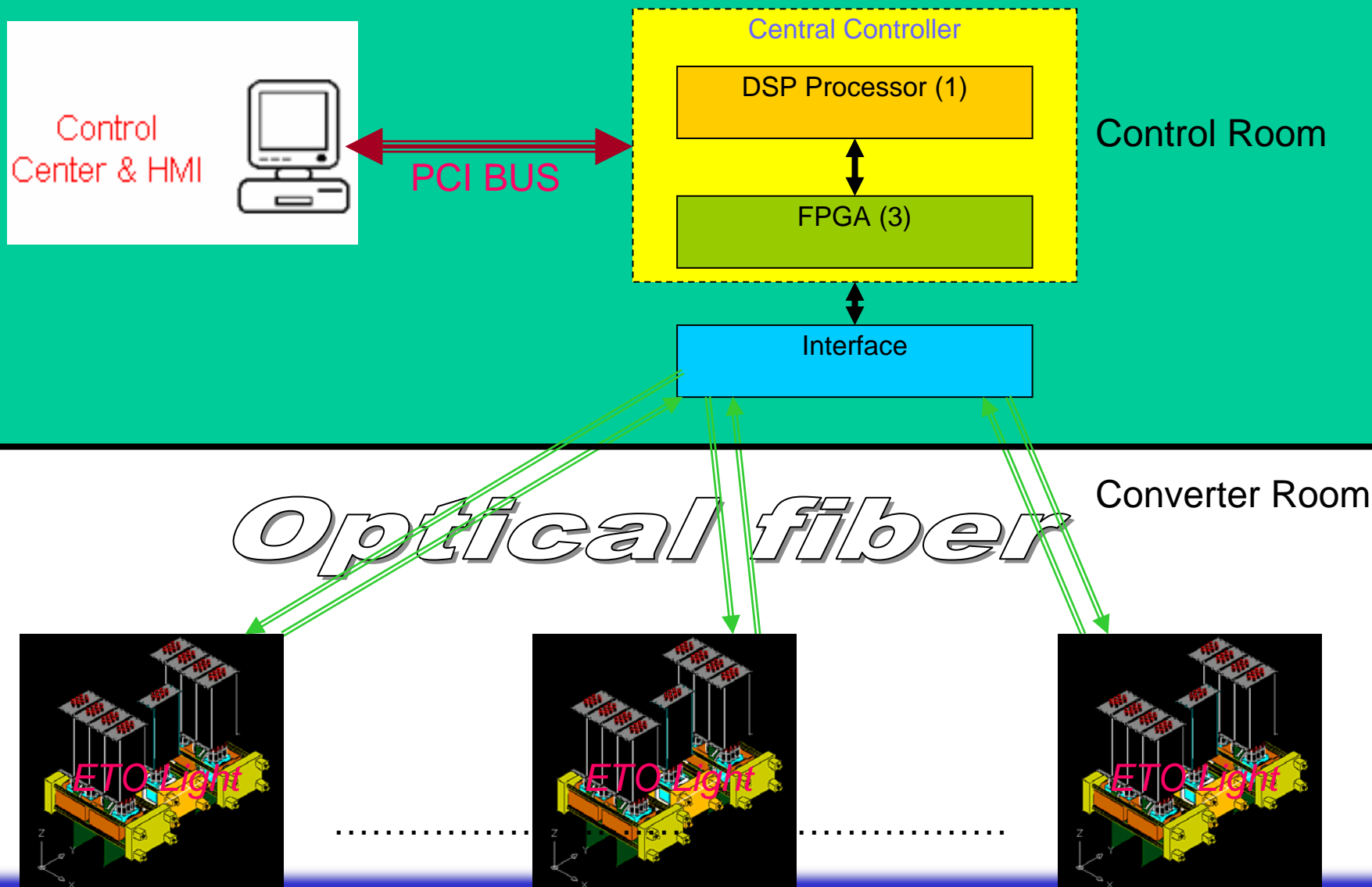


- Built-in digital controller read the voltage value from the **ETO built-in voltage sensor** and carry out the protection function

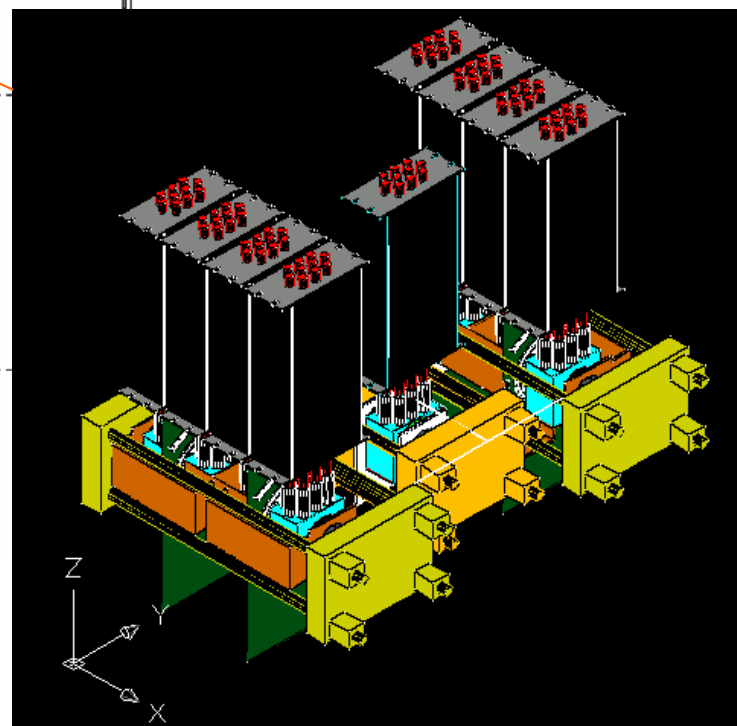
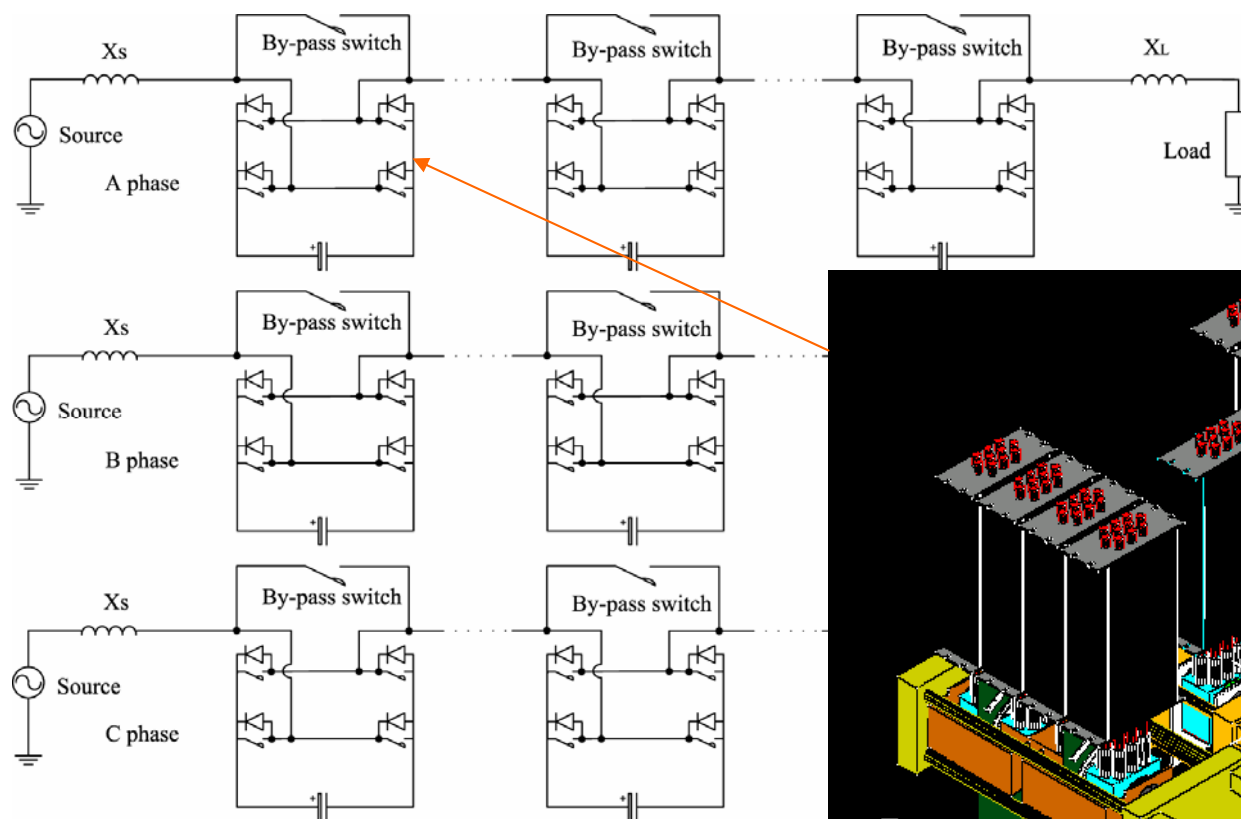




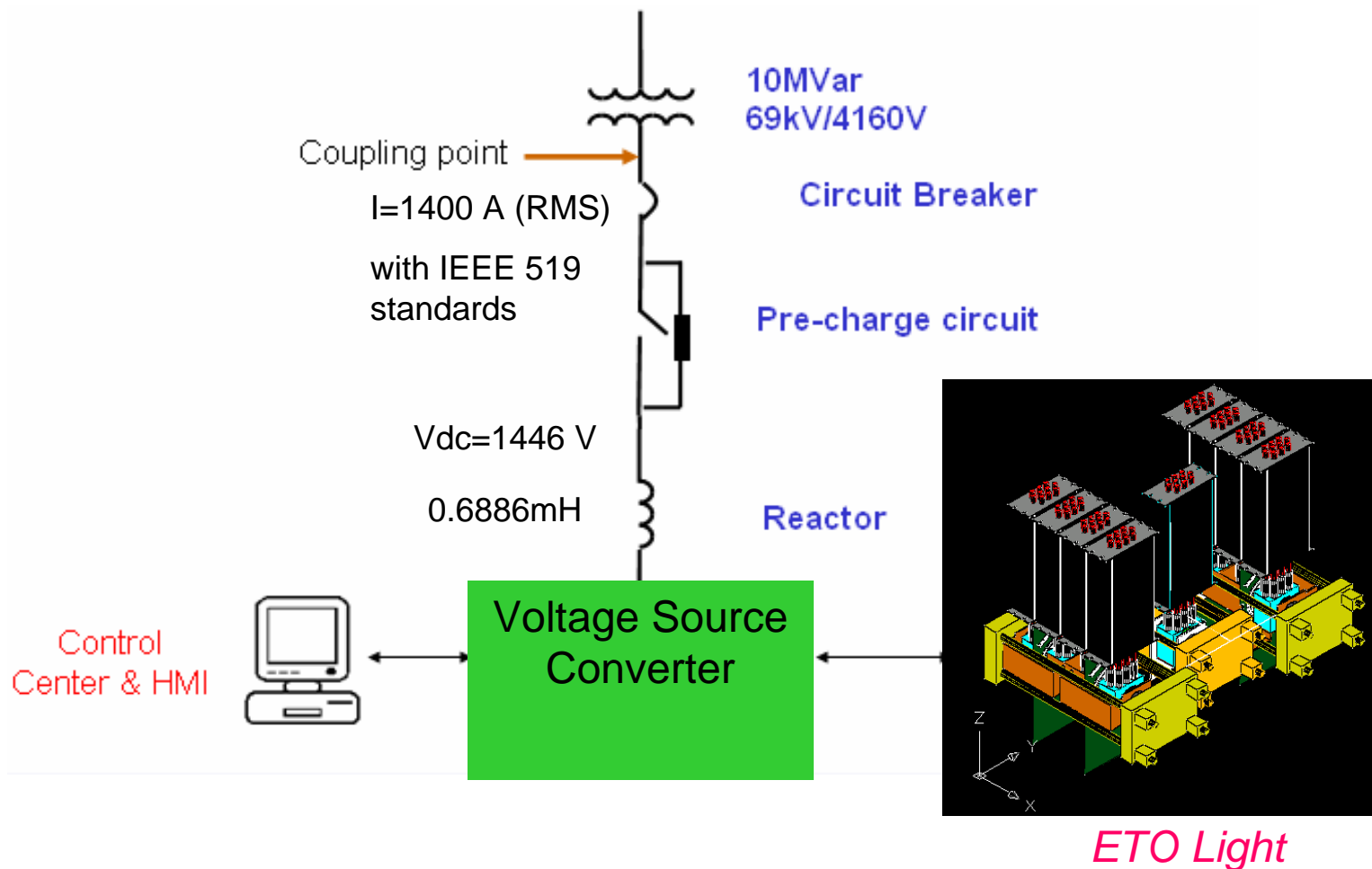
# Enabling Simplified Controller Architecture

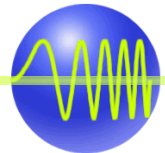


# Example FACTS: A distributed power flow controller based on ETO Light™

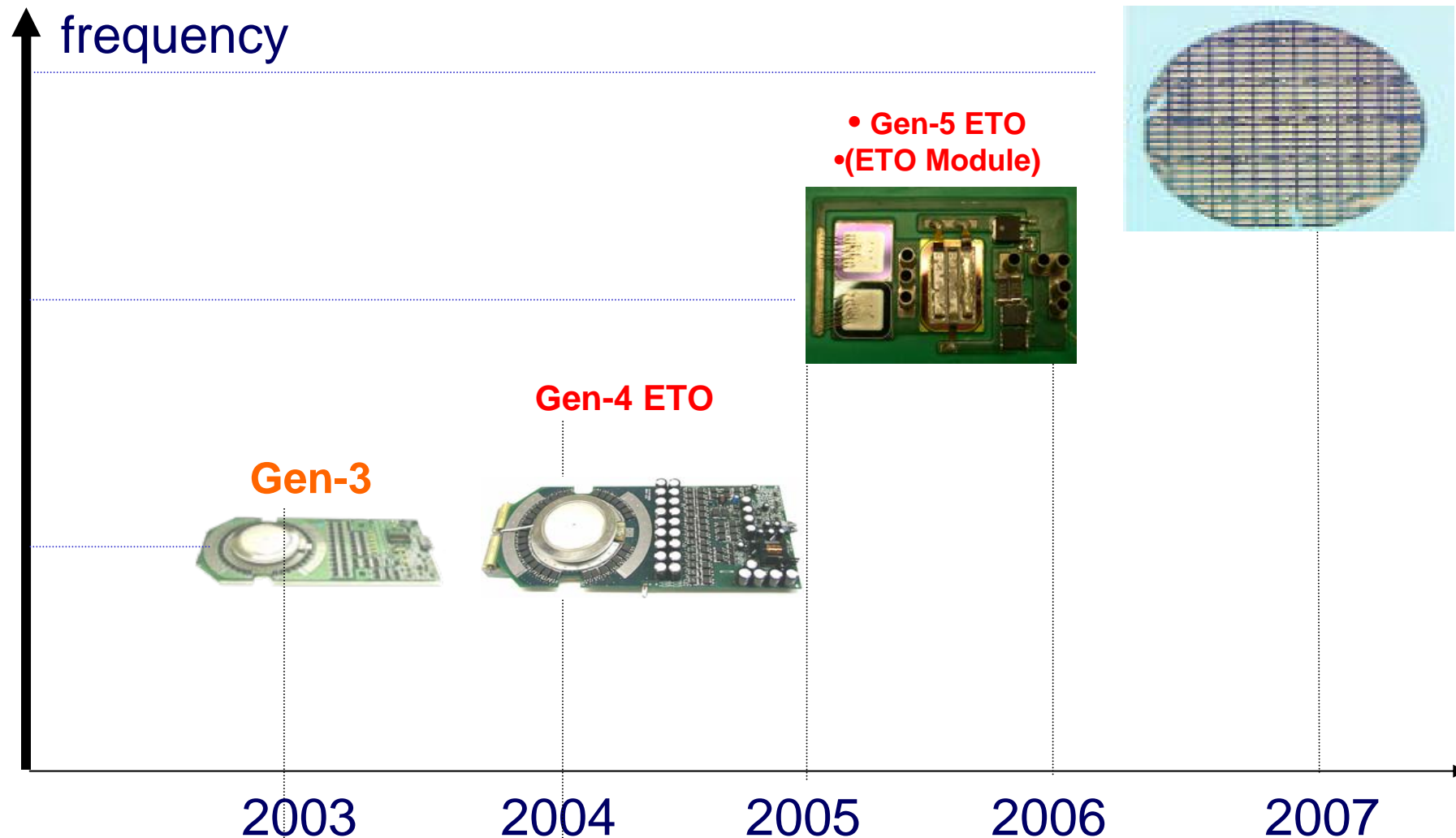


## Future Plan: 10 MVA STATCOM for Wind Farm Application





# Future Plan: SiC IGBT and SiC ETO



Support by DOE's Energy Storage Program has enabled the development of four generations of ETOs, and in FY 2006, has resulted in the development of ETO Light converter. ETO Light modular converter will have the following advantages:

- **Lower cost solution compared to existing solutions based on IGBT and IGCT technologies**
  - Direct material cost of *ETO Light* is estimated to be about \$40,000 excluding DC capacitors. (\$40/kVA to \$20/kVA)
- **High power density solutions compared to existing water cooled systems**
  - 1.6 MVA/m<sup>3</sup> to 3.2 MVA/m<sup>3</sup>
- **Higher reliability due to significantly reduced part counts.**
- **Suitable to FACTS, Energy Storage, Renewable and DG applications**